PROSPECTS FOR A LOCAL DETECTION OF DARK MATTER WITH FUTURE MISSIONS TO URANUS AND NEPTUNE. Lorenz Zwick, Deniz Soyuer and Jozef Bucko, Institute for Computational Science, University of Zurich (zwicklo@ics.uzh.ch, soyuerd@ics.uzh.ch, jozef.bucko@uzh.ch)

Introduction: Past years have seen numerous papers underlining the importance of a space mission to the ice giants in the upcoming decade. Proposed missions to Uranus and Neptune usually involve a ~10 year cruise time to the ice giants. In this phase, the spacecraft trajectories will mainly be determined by the configuration of massive bodies in the solar system. Interplanetary trajectories are monitored by recording Doppler shifts in the time series of the radio link between Earth and the spacecraft. The presence of dark matter (DM) affects the trajectory by introducing a small radial acceleration, which in turn reduces the velocity of the spacecraft over years of interplanetary travel [1]. Additionally, bounds on the precession rate of ice giants could help constrain the local DM density and potentially rule out modified gravity scenarios [2].

Aims: (i) Investigating the possibility of detecting the gravitational influence of DM in the solar system on the trajectory of prospective Doppler ranging missions to Uranus and Neptune, (ii) estimating the constraints such a mission can provide on modified and massive gravity theories via extra-precession measurements using orbiters around the ice giants.

Methods: The precision of these measurements is limited by the noise on the the two-way frequency fluctuation of the Doppler link. For the trajectory deviations, we developed a numerical procedure for reconstructing the influence of DM in the Doppler signal of thousands of simulated ice giant missions. The virtual spacecraft are equipped with ranging systems with differing Allan deviations (a measure of the frequency averaged stability of the Doppler link), and the standard gravitational parameters of the Sun and four giant planets are also sampled under uniform probability distributions centered on their current values. For the extra-precession measurements, we transform uncertainties of ice giant extra-precession rate measurements into constraints on the local dark sector.

Results: *Upper left panel* shows the MCMC constraints for local dark matter density as a function of Allan deviation (purple), along with galactic estimates (grey highlight) and the Cassini Allan deviation. *Bottom left panel* shows the power-law fit of the relative 1σ upper bound uncertainty. *Right panel* shows the 2σ constraints that can be placed on Navarro-Frenk-White (NFW) halo profiles by a prospective ice giant mission without any improvement (solid) and 300 times improvement (dashed) from Cassini-era Allan deviation, by using either the orbital reconstruction method (brown) or extra-precession $\delta\dot{\phi}$ measurements (blue). The grey area corresponds to the parameter space that is currently ruled out by local observations of the Earth's (green) and Mars' (red) orbital precession.

References:

[1] Zwick et al. (2022) *A&A, accepted,* DOI: 10.1051/0004-6361/202243741. [2] Sereno & Jetzer (2006) *MNRAS, 371, 626–632.*